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COUNTERING THE MODERN CONVENTIONAL SUBMARINE IN THE LITTORALS: A NEED FOR JOINT NETWORK-CENTRIC ASW

by

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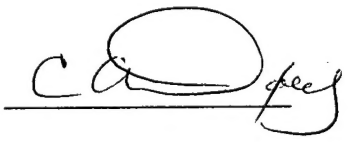
A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

Signature: 

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The modern conventional submarine is an attractive investment for nations seeking maritime security. Technological advances in propulsion, sensor and weapons performance, and sound quieting enable the conventional submarine of an adversary to challenge U.S. access to littoral waters with strategic and operational value. The joint force commander, reliant on sea control and sealift to enable power projection ashore will find his operational planning and execution frustrated by this threat.

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CONTENTS

Abstract of

COUNTERING THE MODERN CONVENTIONAL SUBMARINE IN THE LITTORALS: A NEED FOR JOINT NETWORK-CENTRIC ASW

The modern conventional submarine is an attractive investment for nations seeking maritime security. Technological advances in propulsion, sensor and weapons performance, and sound quieting enable the conventional submarine of an adversary to challenge U. S. access to littoral waters with strategic and operational value. The joint force commander, reliant on sea control and sealift to enable power projection ashore, will find his operational planning and execution frustrated by this threat.

Despite the Chief of Naval Operations' declaration that the U. S. Navy can dominate the undersea environment of the littorals, declining trends in ASW capability are cause for concern; namely, shrinking budgets and force levels, poor sensor performance, and a lack of training in the littorals. The solution for reversing the slide is two-fold. First, a joint combined-arms ASW approach will facilitate a greater number of ASW resources, mitigating the current effects of multi-mission pull. Second, network-centric concepts will enable a joint ASW force to mass effects and achieve simultaneity in order to overwhelm the submarine, hence, negating its stealth.

Achieving this solution first demands the establishment of CINC requirements for a littoral ASW mission and the subsequent generation of joint doctrine. Once in place, the military services must train and equip accordingly to improve upon current littoral ASW capability.

INTRODUCTION

> "ASW capability is essential to ensure free use of the oceans to defend our vital security interests and protect our economic well-being."
>
> U.S. Navy ASW Summary, October 1995[1]

U.S. joint military doctrine emphasizes the preparation for and the conduct of future military operations in the littoral environment. Statistical data portends the national-strategic significance of the environment: over 70 percent of the Earth's population and 80 percent of the world's capitals can be found within 300 miles of a coastline.[2] The landward side of the littoral is where a Joint Force Commander (JFC) will likely find an enemy's center of gravity. Yet, the JFC's ability to establish operational reach and effective maneuver is contingent on controlling the seaward side of the littoral.

U.S. Navy leadership has assured military commanders of the Navy's "ability to dominate the littoral, *including the undersea environment* [emphasis added]..."[3] If this guarantee is predicated on an extrapolation of the U.S. Navy's Cold-War command of the high seas into the littorals, then the JFC should beware.

The U.S. Navy faces a new threat – the modern conventional submarine – in shallow water environments oft forgotten during the heyday of blue-water anti-submarine warfare (ASW). Compound this challenge with increased mission areas in a climate of declining budgets, force levels, and training opportunities, and the Navy's assurance seems vulnerable.

The stakes of losing at littoral ASW are high. A failure to establish this element of sea control can significantly impact the JFC's anticipation and tempo; indeed, the *perceived threat* alone of a hostile submarine can yield equivalent results. Strategic concerns also arise.

Some have offered that one submarine can do more in both military and political damage than any other single conventional threat platform.[4]

It is conceivable that current ASW forces and systems provide the JFC the means to control a modern submarine in the littorals. Nonetheless, the objective is achieved in a manner that robs him of time and freedom of action: an asset-intensive search over sometimes large areas, seeking an opponent able to blend into the local environment.[5] To enhance the JFC's options, this paper recommends a two-element approach to the conduct of littoral ASW. First, the concept of combined-arms ASW—historically, a key to ASW success—must be broadened from a Navy-only mission to a theater-wide integration of joint assets. Second, network-centric principles must be applied to littoral ASW, giving the JFC an unparalleled awareness of the undersea battlespace and removing the stealth of the hostile submarine operating below. Neither element is mutually exclusive—realized together, they are promising means for conducting littoral ASW against the modern conventional submarine.

HOSTILE SUBS IN THE LITTORAL: THE JOINT FORCE'S BOGEYMAN

> "Signature reduction will enhance the ability to engage adversaries anywhere in the battlespace and improve the survivability of forces who employ it. Stealth will strengthen the ability to accomplish surprise, reduce overall force requirements...and make forces less visible to an unsophisticated or disoriented adversary."
>
> Joint Vision 2010, on *friendly capability* due to improved technology[6]

The littoral arena is a tough challenge for ASW platform sensors. The shallow waters preclude long-range detections found in the open seas. Widespread temperature and salinity variations only exacerbate poor acoustic propagation. Bottom irregularities and debris result in a significant number of false sonar contacts; magnetic anomaly detection (MAD) sensors are similarly affected. Increased ambient noise from dense biologic and shipping levels degrades acoustic sensor capability and creates safe havens in which a submarine can hide, e.g. among the coastal fishing fleet.

Submarine exports are increasing worldwide.[7] The difficulty of littoral ASW increases with the introduction of the modern diesel-electric submarine, a platform distinguished by its quiet propulsion, lower return signals from active sonar, and the capability to rest on the bottom. Technological advances have made the conventional submarine an attractive and affordable investment for nations seeking maritime security, be it offensive or defensive. Future improvements in quieting and sensor performance, along with a predicted land-attack capability, will enlarge the hostile submarine's weapons range from the traditional thousands of yards to beyond the horizon.[8] The introduction of the air-independent propulsion (AIP) fuel cell allows a conventional submarine to remain submerged over one month without snorkeling or surfacing.[9] The expanded submerged reach allowed by AIP, along with the extended weapons ranges, present the JFC with a greater operational volume within which to establish sea control.

The modern submarine operating in littoral waters has been compared to a guerilla fighting conventional forces. The submarine's commanding officer can use factors time and space to exploit his opponents' vulnerabilities and to engage at will, afterwards retreating into the environment.[10] An adversary capable of denying the JFC littoral access gains a

tremendous advantage over U.S. forces. The JFC's ability to execute operational maneuver early is jeopardized; his freedom of action becomes restricted by the strategic and operational imperative to solve the "submarine problem."

A submerged adversary may also put the JFC's mission at risk by interdicting the JFC's sea lines of communication (SLOCs). Historical evidence indicates that this is a lucrative option: 95 percent of all material, supplies, and equipment sent to a theater of operations during large-scale conflicts of the twentieth century, including Desert Storm, went by sea.[11] Sealift will continue to be paramount to a military envisioned to "remain largely a force that is based in CONUS."[12] The JFC needs to ensure control of vital SLOCs in order to preserve operational sustainment.

In sum, the modern conventional submarine seriously complicates the JFC's sea control and supply tasks. Unfortunately, current ASW trends have only intensified the difficulty of the problem.

DECLINING TRENDS

> "Many equate ASW to just having a better submarine than the other guy."
>
> VADM James Fitzgerald, USN (Ret)[13]

The U.S. Navy made a large and sustained investment in ASW capability while the Cold War raged. There was a heightened sense of urgency in countering the threat presented by the Soviet submarine force, both strategically (SSBN) and operationally (SSN/SSGN).

With this heavy investment, the Naval aviation, surface, submarine, and surveillance communities consistently conducted successful operations against the Soviets.

After the Cold War, however, the political environment did not support sustained, elevated ASW funding levels. The threat posed by diesel-electric submarines worldwide loomed less than that previously from the former Soviet Union, despite a CNO executive panel's declaration in 1991 that "*the regional ASW threat is not a lesser-included case of the Soviet submarine threat* [emphasis added]."[14] Other mission areas, such as missile defense, gained higher funding priority; ASW lost some of its elegance.

The increased export of advanced submarine technology to rest-of-world nations (ROW) has restored interest in ASW, with a focus now on the littoral environment. The U.S. Navy's ability to conduct littoral ASW, however, is not yet on par with its blue-water prowess of old. In fact, the ASW Requirements and Assessments Division (OPNAV N84) has noted a *decline* in ASW capability. Causes identified included:

- The littoral environment is tough,
- Accelerated submarine technology export to ROW,
- Inadequate sensor and weapons performance in a littoral environment,
- Inadequate ASW systems integration and networking, and
- The "tyranny of multi-mission pull"—its impact on force structure and funding.

The last factor was highlighted by a comparison of the planned number of dedicated ASW forces in an existing campaign plan and the actual number available after accounting for other required missions. The assessment concluded "the status quo is not working."[15]

The British JFC during the Falklands War did not have the benefit of time to learn that blue-water ASW success does not automatically translate into shallow water. Over 10

ships and three ASW helicopter squadrons were employed—the latter continuously—and 240 ASW weapons were expended unsuccessfully against a single conventional submarine with a newly assembled crew and a faulty combat system.[16] A future U.S. JFC will likely have neither the quantity of dedicated ASW assets at his disposal nor the benefit of an unprepared, materially-hampered opponent during military operations. Efforts to change the status quo must be initiated quickly to reverse current trends. An integrated approach of joint combined-arms and a network-centric ASW architecture shows the most promise for mitigating the dilemma.

TAKING BACK THE DEEP, PART I: THE JOINT ELEMENT

> "...ASW proficiency is a national asset, not just a Navy core capability."
>
> ADM Archie Clemins, CINCPACFLT, 1 October 1998[17]

A modern conventional submarine operating in the littorals has an advantage in factors space and time. The JFC must overcome this by establishing favorable force-space and force-time conditions through joint combined-arms ASW.

Combined-arms ASW overwhelms the submarine by its synergistic nature. Each element contributes a unique multiplier: the speed of aviation; the command and control capability and the endurance of the surface ship and its embarked helicopter; the stealth and endurance of the submarine; and the omniscience of intelligence, surveillance, and reconnaissance (ISR)[18]. The qualitative effect can be decisive, resulting in a successful

engagement or simply keeping the submarine at bay. Either outcome enables the JFC to establish sea control.

Joint combined-arms ASW has historical precedent. The defeat of the U-boats in the Atlantic during World War Two was due in large part to the Allies' joint combined-arms ASW operations.[19] Driven by improved Soviet quieting in the 1970s and 1980s, the U.S. Navy refined the combined-arms technique to a coordinated effort by its own assets. ASW prosecution was sequenced to exploit each elemental strength: long-range detection via undersea surveillance; tracking by ship, submarine, aircraft, and helicopter; and localization by maritime patrol aircraft.[20]

During both time frames, military commanders had the luxury of ample forces to execute the ASW mission. With active fleet strength at its lowest level in seven decades, the current challenge of littoral ASW suggests a Navy-only approach is problematic.[21] The coordinated ASW sequence remains valid. The problem—and solution—is to identify national and theater assets available to the JFC that enhance regional ASW capability and to develop doctrine enabling the JFC to better orchestrate a joint combined-arms ASW force in countering the submarine threat.

An examination of joint assets as ASW multipliers can be framed within the U.S. Navy's *Regional ASW Concept of Operations*. Developed to parallel the Defense Planning Guidance phases for a major regional conflict, the Concept of Operations is sequenced in three phases: preparatory, crisis, and conflict.[22] The employment of joint assets in each phase is determined by the defining objective.

Preparatory Phase

This period is characterized by the preparation of the battlespace prior to conflict. The assessment completed during this phase—including intelligence operations, surveillance, and environmental measurements—lays the JFC's groundwork for establishing sea control during later operations. National and theater ISR assets can provide the JFC with near real-time estimates of an adversary's submarine capability and disposition, including submarine maintenance, command and control (C2), and support facilities[23]. On-scene covert SSN surveillance can be augmented by cueing from other regional service elements, including aircraft, special operations force (SOF) elements, and Coast Guard vessels.

A plan to protect SLOCs from the submarine threat should also be developed during this phase. Intelligence preparation of the battlespace (IPB) provides indication of an enemy's capability and likelihood of interdicting SLOCs and focal areas. This enables the JFC to develop deliberate plans, integrating joint elements, for sealift protection instead of adopting a Naval response following the initial "flaming datum."

Crisis Phase

The crisis phase is marked by the build-up of military forces within the theater in anticipation of future conflict. The hostile submarine presents a significant threat to the JFC's operational maneuver and protection during this period. The JFC's actions should attempt to deter an adversary from deploying its submarine; failing this, aggressive prosecution of the threat outside its territorial seas should be conducted.[24]

This phase exemplifies the need for joint combined-arms ASW. If the crisis is unexpected or arises suddenly, an unavailability of Naval forces in the region might

necessitate a "come as your are" approach. The ISR assets used during the preparatory phase would remain vital, continuing to provide battlespace awareness. Joint command and control warfare elements could be employed to deny the hostile submarine critical operational information. Definitive deterrence—destruction of the threat prior to the outbreak of hostilities—could be accomplished by SOF elements, though unlikely in today's geopolitical environment.

The current lack of capable ASW sensors precludes sustained prosecution of a submerged submarine by non-naval assets. Nonetheless, until AIP technology is more widespread, most submarines will periodically need to surface or expose masts in order to charge batteries. Airborne surveillance radars, like that installed on the Joint STARS aircraft, provide not only a means of detecting a surfaced or snorkeling submarine—albeit slight in the latter case—but the emissions from that radar may be sufficient to upset the submarine's freedom of action by keeping it submerged. If nothing else, any "Mark 1 Mod 0 eyeball" onboard a ship or in an aircraft is a potential sensor. The JFC must seek to exploit all available means to maintain battlespace awareness and to establish a controlling tempo of operations prior to conflict.

Hostilities Phase

As hostilities commence, the JFC will continue the actions established during the crisis phase with the intent now to sink or render ineffective the submarine threat. Destruction of the facilities providing the submarine with maintenance, C2, and logistical support should be considered as a tactical objective—an indirect means of neutralizing the threat.

If the threat remains inport at the outbreak of hostilities, strike assets or SOF elements can be used to accomplish the task. If the threat is already operating at sea, naval forces with ASW weapons will likely be required to eliminate the threat. Nevertheless, joint assets employed in maintaining battlespace awareness remain critical to the JFC: (1) the synergy of a joint combined-arms approach can enable the JFC to mass ASW capability at a decisive place and time, instead of squandering it in searching vast areas of the battlespace for the threat, and (2) the employment of joint assets permits traditional Navy ASW forces to execute other missions and tasks, if required, minimizing disruption of the JFC's tempo and balance.

The preceding analysis is rudimentary but illustrates the usefulness of joint combined-arms ASW. Technological advances can jump-start this approach, with selected non-traditional ASW assets being outfitted with acoustic and non-acoustic sensors and ASW weapons systems. All services are having to deal, however, with declining funding levels and multi-mission pull—that is, more for less. Convincing other services to participate more in the ASW mission is difficult, as it is still considered by many as a Navy role.

What is required is doctrine integrating each service and its existing capabilities into a joint combined-arms ASW package. Warfighting CINCs need to be the first out of the blocks, identifying a need as theater forces are organized and trained for other services to participate in the conduct of theater ASW. This is a first step toward effectively countering the modern submarine threat in the littorals; network-centric concepts will provide a leap.

TAKING BACK THE DEEP, PART II: THE NETWORK-CENTRIC ELEMENT

> "...I recently heard a sitting three star describe the solution to ASW as just needing to speed it up! I'm not sure he was aware that the speed of sound in water is somewhat slower than the speed of electrons in air..."
>
> VADM James Fitzgerald, USN (Ret)[25]
>
> "With declining defense budgets, a combined-arms approach that integrates our ASW systems and sensors into a network-centric architecture is imperative."
>
> U.S. Navy 1998 ASW Focus[26]

The second element in countering the modern submarine threat is the application of network-centric warfare (NCW) concepts. With its emphasis on shared awareness, speed of command, and self-synchronization—all enabled by information superiority—NCW has the potential to finally counter the stealth of the submarine. This is, after all, its goal: to stop an opponent in the most direct and discriminate way possible.[27]

The NCW "system of systems"—the coupled network of an information grid, a sensor grid, and an engagement grid—has already been translated into a network-centric ASW vision by the U.S. submarine technology community. Key elements include an increased ability to manage sensor data, an improved detection and classification ability by exploiting the information grid, and real-time battlespace awareness courtesy of a three-dimensional common operational/environmental picture.[28] A theater-level ASW network is forecast, composed of ISR assets, surface ships, submarines, aircraft, command sites, and shore-based support facilities. Technology supporting this vision has not yet matured. Nonetheless, successful U.S. Navy experimentation utilizing a SIPRNET (Secure Internet

Protocol Router Network) web site for the conduct of ASW operations and planning warrants an examination of how network-centric ASW might benefit the JFC.[29]

A robust networking of the joint forces enables the JFC to achieve information superiority over an adversary. Operationally, this translates to heightened shared situational awareness of enemy actions and intentions. The advantages held by the hostile submarine operating in the littorals are mitigated.

Shared awareness permits the JFC to efficiently orchestrate ASW force actions against the threat, achieving a condition of synergy. The JFC can tailor an appropriate-sized force to respond to the submarine, depending on factors space and time—that is, a massing of effects vice force. This becomes critical as force levels shrink and assigned resources become scarce.

The power of information superiority is also vested in the resulting increased speed of command. Defined as "the process by which a superior information position is turned into a competitive advantage," it is paramount to the JFC conducting operations in the littorals.[30] The littoral environment significantly reduces the time available in the JFC's data-to-decision process, due to the close proximity of multi-dimensional threats. An ability to check an adversary's options before he can act against the joint force is invaluable.

Self-synchronization is another component of NCW. It is characterized by well-informed forces able to recognize and act on a situation without further direction to meet commander's intent.[31] The degree of simultaneity achieved by a self-synchronized joint combined-arms ASW force would tend to overwhelm the hostile submarine. Recent U.S. Navy assessments indicate the only reliable means of protecting ships from submarines is to *avoid contact*, either removing the threat by attrition or by purposely operating away from

the threat.[32] Network-centric ASW erases this conviction, favoring the offensive at the operational and tactical levels.

Speed of command and self-synchronization enable the JFC to engage the submarine threat in an unpredictable manner. The element of surprise neutralizes the submarine's freedom of action. It can no longer operate in a guerilla-like fashion. The JFC may elect to accelerate the tempo of ASW operations, unrelenting in an attempt to exploit the vulnerability of the small submarine crew—its physical endurance.[33]

Network-centric ASW benefits the JFC's application of operational art. He can remove the stealth of the submarine operating in the littoral rapidly and decisively, permitting sea control to be established quicker. The JFC's capability to maneuver remains preserved and the threat to his operational sustainment is eliminated.

Nevertheless, some issues concerning NCW's supporting principles remain. First, the quality of a common operational picture used in a decision-making process is a function of the accuracy of the data from which it was derived. Current ASW sensor performance in the littorals is deemed lacking.[34] The sensor grid is held hostage by the inability to reliably detect and classify a modern conventional submarine. Technology advances and improved knowledge of the littoral environment can provide a fix, but this will take time.

Second, superior battlespace awareness may prove a pitfall to the JFC who fails to regard economy of effort. Once the submarine's stealth is stripped away, the JFC must identify if it is an immediate threat to his center of gravity and act accordingly. Attempting to destroy every submarine in the battlespace may not be necessary. Resources for other mission areas are wasted and doing so only reverts to classical attrition-based warfare.

Last, a prerequisite for self-synchronization is a supporting doctrine that facilitates bottom-up actions.[35] That doctrine does not exist today and may be a ways off, as indicated by the prevailing debates on perceived loss of autonomy and the potential for undue higher-echelon oversight resulting from NCW. Development of doctrine for integrated littoral operations underpins the success of network-centric ASW. Technology is merely a means to facilitate network-centric ASW; organization and training remain critical to ASW operations.

CONCLUSIONS

> "Uncertainty over submarine deployments must not be allowed to determine operational tempo or operational area as uncertainty over underwater mining did during Desert Storm."
>
> U.S. Navy 1997 Anti-Submarine Warfare Assessment[36]

Future military operations will find the JFC projecting power ashore from a littoral environment. His plans to establish sea control and to sustain strategic mobility must account for the modern conventional submarine operating in the shallow littoral waters. Theater ASW is critical to preserving operational maneuver.

The U.S. Navy today arguably remains able to counter ROW submarine forces in international waters of strategic and operational interest. At best, the margin is beginning to narrow, compressed by shrinking force levels and funding, a lack of ASW experience in the littoral environment, and increasing ROW submarine exports.

Undoubtedly, with U.S. military leadership acknowledging a perceived public expectation for quick and efficient military victories, the momentum towards a network-

centric force will increase. The advantages of NCW improve the JFC's ability to counter the modern conventional submarine; however, network-centric ASW is only an enabler. Technology alone will not defeat the hostile submarine—superior ASW systems do not guarantee superior ASW capability.

Attempts at quick fixes to counter the modern submarine threat, such as fragmented equipment installations or ad hoc measures to conduct joint ASW, will not enable future success. A methodical approach that dovetails joint combined arms and NCW must be adopted:

- First, theater CINCs need to highlight the problem by establishing requirements for a joint combined-arms ASW mission.
- Once these requirements are generated, joint doctrine for littoral ASW must be developed in conjunction with the military services. The doctrine needs to reflect the benefits made available by NCW.
- Last, the services must train and equip in accordance with established doctrine. Joint assets, organized as a network-centric force, must be afforded every opportunity to conduct combined-arms ASW in a littoral environment, as real-world operations and exercises permit.

NOTES

[1] Department of the Navy, ASW Summary (1995) (Washington, DC: 1995), 3.

[2] Milan N. Vego, Naval Strategy and Operations in Narrow Seas (London: Frank Cass, 1999), 184.

[3] Department of the Navy, Forward...From the Sea: The Navy Operational Concept (Washington, DC: March 1997), 7.

[4] MIT Security Studies Program, Antisubmarine Warfare After the Cold War (Cambridge: MIT Press, 1997), 11.

[5] Ibid., 13.

[6] Joint Chiefs of Staff, Joint Vision 2010 (Washington, DC: 1995), 12-13.

[7] Of note, submarines were the only weapons export to increase worldwide between 1991 and 1996; James R. Fitzgerald, "About Anti-Submarine Warfare," The Submarine Review, April 1997, 7:

[8] ASW Summary (1995), 6; Department of the Navy, OPNAV N84, 1997 Anti-Submarine Warfare Assessment, Vol. 3, Intelligence Assessment: The Submarine Threat Out to 2016 (Washington, DC: 1997), 145.

[9] Vego, 297; John Vlattas, "Shifting from Blue to Brown: Pursuing the Diesel Submarine into the Littoral," The Submarine Review, April 1999, 93.

[10] ASW Summary (1995), 6.

[11] Forward...From the Sea: The Navy Operational Concept, 9.

[12] Joint Vision 2010, 4.

[13] Fitzgerald, 9.

[14] Shallow Water ASW Task Force findings of 6 August 1991; Harvey Spivack et al., Lessons Learned from Recent ASW Studies and Analyses (Alexandria, VA: Center for Naval Analyses, April 1997), 153-54.

[15] Department of the Navy, OPNAV N84, "A Joint Campaign Analysis and ASW Integration," Brief, COMTHIRDFLT ASW Round Table: 21-22 January 1999, <http://www.coronado.navy.smil.mil/j3/j32/ASWRound/ASWRNDTB1/> (8 January 2000) (hereafter indicated as "A Joint Campaign Analysis and ASW Integration").

[16] The Argentine Navy Type 209 *San Luis* patrolled in vicinity of the Falkland Islands for one month prior to and during the conflict. It conducted an unsuccessful attack, on 11 May 1982, against the Royal Navy frigates *Alacrity* and *Arrow*. Fire control system problems precluded generating automatic firing solutions on the ships; manual solutions were generated. A single torpedo was fired using, at the commanding officer's discretion, sonar vice visual bearings. The guide wire for the torpedo broke shortly after launch. The opening speed and course of the frigates did not permit a second shot; David Brown, The Royal Navy and the Falklands War (Annapolis, MD: Naval Institute Press, 1987), 156-57; Robert D. Ford, "The Excedrin Headache of ASW: From U-boats to the New Boats," (Unpublished Research Paper, U.S. Naval War College, Newport, RI: 1997), 10.

[17] Quoted in "A Joint Campaign Analysis and ASW Integration."

[18] Fitzgerald, 6.

[19] Allied services employed were: U.S. Navy, U.S. Army Air Force, and U.S. Coast Guard; Royal Navy and Royal Air Force; and Royal Canadian Navy and Royal Canadian Air Force; Samuel E. Morison, History of United States Naval Operations in World War II, Vol. X, The Atlantic Battle Won: May 1943 – May 1945 (Boston: Little, Brown and Company, 1956), ix, 361; Charles M. Sternhell and Alan M. Thorndike. Antisubmarine Warfare in World War II (Operations Evaluation Group Report No. 51), (Washington, DC: Navy Department, 1946), 62.

[20] MIT Security Studies Program, 8.

[21] The ASW mission of the S-3B Viking was terminated in FY 99. SSN levels, at 56 in FY 00, will shrink to 50 in accordance with the FYDP; maintaining this level assumes a constant rate of production of two *Virginia*-class SSNs per year. Initial low-rate production of the SH-60R littoral warfare helicopter is scheduled for March 2000; Wendy Leland, "SH-60R Rolls Out," Naval Aviation News, November/December 1999, 7; Department of Defense, Report of the Secretary of Defense to the President and the Congress: 1999 (Washington, DC: 1999), 45, 59.

[22] ASW Summary (1995), 8-11.

[23] John S. Husaim, "Antisubmarine Warfare in the Littoral: An Essential Element of Battlespace Dominance?" (Unpublished Research Paper, U.S. Naval War College, Newport, RI: 1995), 18.

[24] ASW Summary (1995), 11.

[25] Fitzgerald, 4.

[26] John P. Walman, "Controlling the Undersea Battlespace in the Littorals," Sea Power, March 1999, 38.

[27] Arthur K. Cebrowski, "Network-Centric Warfare: An Emerging Military Response to the Information Age," Paper presented at the 1999 Command and Control Research and Technology Symposium: 29 June 1999, 2.

[28] James R. Fitzgerald, Raymond J. Christian, and Robert C. Manke, "Network-Centric Antisubmarine Warfare," U.S. Naval Institute Proceedings, September 1998, 93; Larry H. Green and Barry E. Raff, "Net-Centric Undersea Warfare," Sea Technology, November 1999, 20-22.

[29] The Web-based ASW Network (WeCAN) was tested and validated during the Navy's Fleet Battle Experiment ECHO in March-April 1999. The web site made available to all subscribers a common tactical picture, environmental data, acoustic predictions, and commander's intentions. Chat capability was also made available; Frank C. Borik, "The Silent Service is On the Air: How Advanced Communications Will Revolutionize Submarine Warfare," The Submarine Review, July 1999, 105-6.

[30] Cebrowski, 4.

[31] Ibid., 4.

[32] Department of the Navy, OPNAV N84, 1997 Anti-Submarine Warfare Assessment, Vol. 4, Analysis Supplement (Washington, DC: 1997), 95.

[33] Tim Sloth Joergensen, "U.S. Navy Operations in Littoral Waters: 2000 and Beyond," Naval War College Review LI, no. 2, Spring 1998, 26.

[34] Spivack et al., 12; "A Joint Campaign Analysis and ASW Integration."

[35] Cebrowski, 4.

[36] 1997 Anti-Submarine Warfare Assessment, Vol. 4, Analysis Supplement, 96.

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